



## HAC RF EMISSIONS TEST REPORT

**FCC 47 CFR § 20.19  
ANSI C63.19-2011**

*For*  
**SMARTPHONE**

**FCC ID: BCG-E3238A  
Model Name: A2106**

**Report Number: 12258201-S4V1  
Issue Date: 8/23/2018**

*Prepared for*  
**APPLE, INC.  
1 APPLE PARK WAY  
CUPERTINO, CA 95014, U.S.A.**

*Prepared by*  
**UL VERIFICATION SERVICES INC.  
47173 BENICIA STREET  
FREMONT, CA 94538, U.S.A.  
TEL: (510) 771-1000  
FAX: (510) 661-0888**



NVLAP LAB CODE 200065-0

**Revision History**

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| V1   | 8/23/2018 | Initial Issue | --         |
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## 1. Attestation of Test Results

|                      |                                        |
|----------------------|----------------------------------------|
| Applicant Name       | APPLE, INC.                            |
| FCC ID               | BCG-E3238A                             |
| Model Name           | A2106                                  |
| Applicable Standards | FCC 47 CFR § 20.19<br>ANSI C63.19-2011 |
| HAC Rating           | M3                                     |
| Date Tested          | 7/19/2018 to 7/21/2018                 |
| Test Results         | Pass                                   |

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

**Note:** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government (NIST Handbook 150, Annex A). This report is written to support regulatory compliance of the applicable standards stated above.

|                                                                                                               |                                                                                                     |
|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| Approved & Released By:<br> | Prepared By:<br> |
| Devin Chang<br>Senior Test Engineer<br>UL Verification Services Inc.                                          | Chakrit Thammanavarat<br>Test Engineer<br>UL Verification Services Inc.                             |

## 2. Test Methodology

The tests documented in this report were performed in accordance with ANSI C63.19-2011 Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids and FCC Published procedure

KDB 285076 D01 HAC Guidance v05

KDB 285076 D03 HAC FAQ v01

TCB workshop updates

## 3. Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at

|                      |                      |
|----------------------|----------------------|
| 47173 Benicia Street | 47266 Benicia Street |
| SAR Lab C            | SAR Lab 2            |

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0.

## 4. Calibration and Uncertainty

### 4.1. Measuring Instrument Calibration

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

| Name of Equipment            | Manufacturer | Type/Model             | Serial No. | Cal. Due Date |
|------------------------------|--------------|------------------------|------------|---------------|
| Synthesized Signal Generator | Agilent      | N5181A                 | MY50140630 | 5/25/2019     |
| Power Meter                  | HP           | 437B                   | 3125U12345 | 8/10/2018     |
| Power Meter                  | HP           | 437B                   | 3125U11347 | 8/15/2018     |
| Power Sensor                 | HP           | 8481A                  | 1926A27048 | 8/10/2018     |
| Power Sensor                 | HP           | 8481A                  | 3318A92374 | 8/15/2018     |
| Amplifier                    | MITEQ        | AMF-4D-00400600-50-30P | 1795092    | N/A           |
| Directional coupler          | Werlatone    | C8060-102              | 2141       | N/A           |
| DC Power Supply              | HP           | 1611                   | 215-02292  | N/A           |
| Data Acquisition Electronics | SPEAG        | DAE4                   | 1472       | 3/8/2019      |
| E-Field Probe*               | SPEAG        | EF3DV3                 | 4041       | 3/16/2019     |
| Calibration Dipole           | SPEAG        | CD835V3                | 1014       | 2/8/2019      |
| Calibration Dipole           | SPEAG        | CD1880V3               | 1122       | 2/8/2019      |
| Calibration Dipole           | SPEAG        | CD2450V3               | 1014       | 2/8/2019      |
| Calibration Dipole           | SPEAG        | CD2600V3               | 1014       | 8/18/2018     |
| Calibration Dipole           | SPEAG        | CD5500V3               | 1008       | 5/16/2019     |
| Radio Communication Tester   | R & S        | CMW 500                | 125236     | 2/21/2019     |

#### Note(s):

\*: According to SPEAG's Technical Report, "MIF Verification", Doc # TR-FB-12.09.04-1, issued date: 9/4/2012. E-field probes are calibrated with specified uncertainty according to ISO 17025 as described in their calibration certificate. The MIF according to the definition in ANSI C63.19 is specific for a modulation and can therefore be used as a constant value if the probe has been PMR calibrated.

## 4.2. Measurement Uncertainty

| Error Description                                                          | Uncertainty value ( $\pm\%$ ) | Probe Dist. | Div.  | (Ci) E | Std. Unc.( $\pm\%$ ) E |
|----------------------------------------------------------------------------|-------------------------------|-------------|-------|--------|------------------------|
| <b>Measurement System</b>                                                  |                               |             |       |        |                        |
| Probe Calibration                                                          | 5.1                           | N           | 1     | 1      | 5.1                    |
| Axial Isotropy                                                             | 4.7                           | R           | 1.732 | 1      | 2.7                    |
| Sensor Displacement                                                        | 16.5                          | R           | 1.732 | 1      | 9.5                    |
| Boundary Effects                                                           | 2.4                           | R           | 1.732 | 1      | 1.4                    |
| Phantom Boundary Effects                                                   | 7.2                           | R           | 1.732 | 1      | 4.1                    |
| Linearity                                                                  | 4.7                           | R           | 1.732 | 1      | 2.7                    |
| Scaling to PMR Calibration                                                 | 10.0                          | R           | 1.732 | 1      | 5.8                    |
| System Detection Limit                                                     | 1.0                           | R           | 1.732 | 1      | 0.6                    |
| Readout Electronics                                                        | 0.3                           | N           | 1     | 1      | 0.3                    |
| Response Time                                                              | 0.8                           | R           | 1.732 | 1      | 0.5                    |
| Integration Time                                                           | 2.6                           | R           | 1.732 | 1      | 1.5                    |
| RF Ambient Conditions                                                      | 3.0                           | R           | 1.732 | 1      | 1.7                    |
| RF Reflections                                                             | 12.0                          | R           | 1.732 | 1      | 6.9                    |
| Probe Positioner                                                           | 1.2                           | R           | 1.732 | 1      | 0.7                    |
| Probe Positioning                                                          | 4.7                           | R           | 1.732 | 1      | 2.7                    |
| Extrapolation and Interpolation                                            | 1.0                           | R           | 1.732 | 1      | 0.6                    |
| <b>Test sample Related</b>                                                 |                               |             |       |        |                        |
| Test Positioning Vertical                                                  | 4.7                           | R           | 1.732 | 1      | 2.7                    |
| Test Positioning Lateral                                                   | 1.0                           | R           | 1.732 | 1      | 0.6                    |
| Device Holder and Phantom                                                  | 2.4                           | R           | 1.732 | 1      | 1.4                    |
| Power Drift                                                                | 5.0                           | R           | 1.732 | 1      | 2.9                    |
| <b>Phantom and Setup Related</b>                                           |                               |             |       |        |                        |
| Phantom Thickness                                                          | 2.4                           | R           | 1.732 | 1      | 1.4                    |
| Combined Std. Uncertainty                                                  |                               |             |       |        | 16.3                   |
| <b>Expanded Std. Uncertainty on Power (Coverage Factor for 95%, k = 2)</b> |                               |             |       |        | <b>32.6</b>            |
| <b>Expanded Std. Uncertainty on Field</b>                                  |                               |             |       |        | <b>16.3</b>            |
| Notes for table                                                            |                               |             |       |        |                        |
| 1. N - Nomal                                                               |                               |             |       |        |                        |
| 2. R - Rectangular                                                         |                               |             |       |        |                        |
| 3. Div. - Divisor used to obtain standard uncertainty                      |                               |             |       |        |                        |
| 4. Ci - is te sensitivity coefficient                                      |                               |             |       |        |                        |

## 5. System Specifications

E-field measurements are performed using the DASY52 automated dosimetric assessment system. The DASY52 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland.

The DASY52 HAC Extension consists of the following parts:

### Test Arch Phantom

The specially designed Test Arch allows high precision positioning of both the device and any of the validation dipoles.

### EF3DV3 Isotropic E-Field Probe

|                |                                                                                                                                                                                             |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Construction:  | One dipole parallel, two dipoles normal to probe axis<br>Interleaved sensors<br>Built-in shielding against static charges<br>PEEK enclosure material                                        |
| Calibration:   | In air from 100 MHz to 3.0 GHz (absolute accuracy $\pm 6.0\%$ , $k=2$ )<br>ISO/IEC 17025 <u>calibration service</u> available.                                                              |
| Frequency:     | 40 MHz – >6 GHz (can be extended to < 20 MHz);<br>Linearity: $\pm 0.2$ dB (100 MHz – 3 GHz)                                                                                                 |
| Directivity:   | $\pm 0.2$ dB in air (rotation around probe axis)<br>$\pm 0.4$ dB in air (rotation normal to probe axis)                                                                                     |
| Dynamic Range: | 2 V/m to > 1000 V/m; Linearity: $\pm 0.2$ dB                                                                                                                                                |
| Dimensions:    | Overall length: 337 mm (Tip: 20 mm)<br>Tip diameter: 3.9 mm (Body: 12 mm)<br>Distance from probe tip to dipole centers: 1.5 mm<br>Sensor displacement to probe's calibration point: <0.7 mm |
| Application:   | General near-field measurements up to 6 GHz<br>HAC measurements up to 6 GHz<br>Field component measurements<br>Fast automatic scanning in phantoms                                          |

## 6. System Validation

The test setup was validated when first configured and verified periodically thereafter to ensure proper function. The procedure provided in this section is a validation procedure using dipole antennas for which the field levels were computed by numeric modeling.

Procedure:

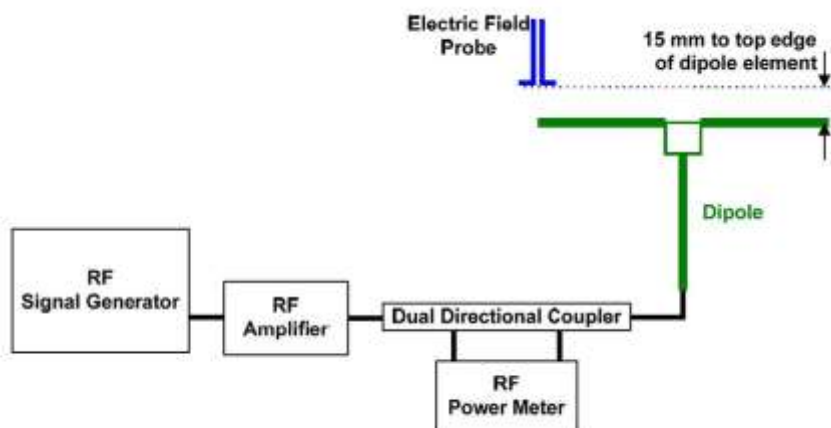
Place a dipole antenna meeting the requirements given in ANSI C63.19 in the normally occupied by the WD.

The dipole antenna serves as a known source for an electrical and magnetic output. Position the E-field probe so that the following occurs:

- The probes and their cables are parallel to the coaxial feed of the dipole antenna
- The probe cables and the coaxial feed of the dipole antenna approach the measurement area from opposite directions
- The center point of the probe element(s) is 15 mm from the closest surface of the dipole elements.

Scan the length of the dipole with the E-field probe and record the two maximum values found near the dipole ends. Average the two readings and compare the reading to the expected value in the calibration certificate or the expected value in this standard.

**Setup diagram**





## 6.1. System Validation Results

| SAR Lab | Date      | Dipole Type_Serial #_Freq.  | Dipole Cal. Due Data | Max. measured from   |                     | Average max. above arm (V/m) | Target (V/m) (From SPEAG) | Deviation (note 1) ± % | Plot No. |
|---------|-----------|-----------------------------|----------------------|----------------------|---------------------|------------------------------|---------------------------|------------------------|----------|
|         |           |                             |                      | above high end (V/m) | above low end (V/m) |                              |                           |                        |          |
| C       | 7/19/2018 | CD835V3_SN:1014_(835 MHz)   | 2/8/2019             | 117.00               | 112.90              | 114.95                       | 108.90                    | 5.56                   | 1        |
| C       | 7/19/2018 | CD1880V3_SN:1122_(1880 MHz) | 2/8/2019             | 89.42                | 94.26               | 91.84                        | 88.40                     | 3.89                   | 2        |
| C       | 7/19/2018 | CD2600V3_SN:1014_(2600 MHz) | 8/18/2018            | 94.49                | 93.28               | 93.89                        | 87.30                     | 7.54                   | 3        |
| C       | 7/19/2018 | CD2450V3_SN:1014_(2450 MHz) | 2/8/2019             | 93.60                | 93.93               | 93.77                        | 88.00                     | 6.55                   | 4        |
| C       | 7/19/2018 | CD5500V3_SN:1008_(5500 MHz) | 5/16/2019            | 100.80               |                     | 100.80                       | 98.90                     | 1.92                   | 5        |

### Notes:

- 1) Delta (Deviation) % = 100 \* (Measured value minus Target value) divided by the Target value. Deltas within ±25% are acceptable, of which 12% is deviation and 13% is measurement uncertainty.
- 2) The maximum E-field or were evaluated and compared to the target values provided by SPEAG in the calibration certificate of specific dipoles.
- 3) Please refer to the appendix for detailed measurement data and plots.

## 7. Average Antenna Input Power & Evaluation for Low-power Exemption

An RF air interface technology of a device is exempt from testing when its average antenna input power(Max tune-up limit) plus its **MIF is  $\leq 17$  dBm** for any of its operating modes. If a device supports multiple RF air interfaces, each RF air interface shall be evaluated individually.

Power measurements were performed in accordance to the device's two power modes, Mode A and Mode B for each antenna. Mode A power is used when the device is used against the user's head or away from the body. Mode B power is used when the device is used in a Body-worn configuration by the user. The selection between antennas ANT1, ANT2, ANT4 and ANT5 in the application is based on RSSI based antenna selection. The full details of power selections are described in the operational description.

### 7.1. ANT1

| Air-Interface               | Average Antenna Input Power (dBm) | Worst Case MIF (dB) | Input Power plus its MIF (dBm) | HAC Tested |
|-----------------------------|-----------------------------------|---------------------|--------------------------------|------------|
| GSM850                      | 30.0                              | 3.63                | 33.63                          | Yes        |
| GSM1900                     | 30.0                              | 3.63                | 33.63                          | Yes        |
| W-CDMA Band II              | 25.5                              | -27.23              | -1.73                          | No         |
| W-CDMA Band IV              | 25.5                              | -27.23              | -1.73                          | No         |
| W-CDMA Band V               | 25.5                              | -27.23              | -1.73                          | No         |
| CDMA BC0                    | 25.5                              | 3.26                | 28.76                          | Yes        |
| CDMA BC1                    | 25.5                              | 3.26                | 28.76                          | Yes        |
| CDMA BC10                   | 25.5                              | 3.26                | 28.76                          | Yes        |
| LTE Band 2                  | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 4                  | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 5                  | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 7                  | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 12                 | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 13                 | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 14                 | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 17                 | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 25                 | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 26                 | 25.5                              | -9.76               | 15.74                          | No         |
| LTE Band 30                 | 23.5                              | -9.76               | 13.74                          | No         |
| LTE Band 41 PC3             | 25.5                              | -1.44               | 24.06                          | Yes        |
| LTE Band 41 PC2             | 27.0                              | -1.44               | 25.56                          | Yes        |
| LTE Band 66                 | 25.5                              | -9.76               | 15.74                          | No         |
| LTE CA 7C <sup>1</sup>      | 25.0                              | -9.76               | 15.24                          | No         |
| LTE CA 41C PC3 <sup>1</sup> | 25.0                              | -1.44               | 23.56                          | No         |

#### Notes:

1. Testing for ULCA is not required because it uses same Tx band, modulations, and output power is equal or less than non-CA modes.

**7.2. ANT2**

| Air-Interface                | Average Antenna Input Power (dBm) | Worst Case MIF (dB) | Input Power plus its MIF (dBm) | HAC Tested |
|------------------------------|-----------------------------------|---------------------|--------------------------------|------------|
| GSM850                       | 28.0                              | 3.63                | 31.63                          | Yes        |
| GSM1900                      | 27.5                              | 3.63                | 31.13                          | Yes        |
| W-CDMA Band II               | 19.5                              | -27.23              | -7.73                          | No         |
| W-CDMA Band IV               | 20.7                              | -27.23              | -6.53                          | No         |
| W-CDMA Band V                | 24.2                              | -27.23              | -3.03                          | No         |
| CDMA BC0                     | 24.2                              | 3.26                | 27.46                          | Yes        |
| CDMA BC1                     | 19.5                              | 3.26                | 22.76                          | Yes        |
| CDMA BC10                    | 24.2                              | 3.26                | 27.46                          | Yes        |
| LTE Band 2                   | 19.5                              | -9.76               | 9.74                           | No         |
| LTE Band 4                   | 20.7                              | -9.76               | 10.94                          | No         |
| LTE Band 5                   | 23.5                              | -9.76               | 13.74                          | No         |
| LTE Band 7                   | 19.7                              | -9.76               | 9.94                           | No         |
| LTE Band 12                  | 24.2                              | -9.76               | 14.44                          | No         |
| LTE Band 13                  | 23.7                              | -9.76               | 13.94                          | No         |
| LTE Band 14                  | 24.2                              | -9.76               | 14.44                          | No         |
| LTE Band 17                  | 24.2                              | -9.76               | 14.44                          | No         |
| LTE Band 25                  | 19.5                              | -9.76               | 9.74                           | No         |
| LTE Band 26                  | 23.5                              | -9.76               | 13.74                          | No         |
| LTE Band 30                  | 19.5                              | -9.76               | 9.74                           | No         |
| LTE Band 41 PC3              | 21.2                              | -1.44               | 19.76                          | Yes        |
| LTE Band 41 PC2 <sup>2</sup> | 21.2                              | -1.44               | 19.76                          | No         |
| LTE Band 66                  | 20.7                              | -9.76               | 10.94                          | No         |
| LTE CA 7C <sup>1</sup>       | 19.7                              | -9.76               | 9.94                           | No         |
| LTE CA 41C PC3 <sup>1</sup>  | 21.2                              | -1.44               | 19.76                          | No         |
| 802.11b                      | 19.8                              | -2.02               | 17.73                          | Yes        |
| 802.11g                      | 19.8                              | 0.12                | 19.87                          | Yes        |

**Notes:**

1. Testing for ULCA is not required because it uses same Tx band, modulations, and output power is equal or less than non-CA modes.
2. LTE band 41 PC2 testing is not required because PC2 has the same power limit but a lower duty cycle than PC3.

**7.3. ANT4**

| Air-Interface      | Average Antenna Input Power (dBm) | Worst Case MIF (dB) | Input Power plus its MIF (dBm) | HAC Tested |
|--------------------|-----------------------------------|---------------------|--------------------------------|------------|
| 802.11a (U-NII-1)  | 21.00                             | -3.15               | 17.85                          | Yes        |
| 802.11a (U-NII-2A) | 21.00                             | -3.15               | 17.85                          | Yes        |
| 802.11a (U-NII-2C) | 21.00                             | -3.15               | 17.85                          | Yes        |
| 802.11a (U-NII-3)  | 21.50                             | -3.15               | 18.35                          | Yes        |

**7.4. ANT5**

| Air-Interface      | Average Antenna Input Power (dBm) | Worst Case MIF (dB) | Input Power plus its MIF (dBm) | HAC Tested |
|--------------------|-----------------------------------|---------------------|--------------------------------|------------|
| 802.11b            | 22.0                              | -2.02               | 19.98                          | Yes        |
| 802.11g            | 21.5                              | 0.12                | 21.62                          | Yes        |
| 802.11a (U-NII-1)  | 21.0                              | -3.15               | 17.85                          | Yes        |
| 802.11a (U-NII-2A) | 21.0                              | -3.15               | 17.85                          | Yes        |
| 802.11a (U-NII-2C) | 21.0                              | -3.15               | 17.85                          | Yes        |
| 802.11a (U-NII-3)  | 21.5                              | -3.15               | 18.35                          | Yes        |



## 8. Device Under Test

|                  |                                 |
|------------------|---------------------------------|
| Normal operation | Held to head                    |
| Back Cover       | The Back Cover is not removable |

### 8.1. Air Interfaces and Operating Mode

| Air Interface                                                                                                                                      | Bands (MHz)     | Type | C63.19 Tested   | Simultaneous Transmitter                               | OTT Testing Required? Name of Voice Service | GSM 1900 MHz Power Reduction |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------|-----------------|--------------------------------------------------------|---------------------------------------------|------------------------------|
| GSM                                                                                                                                                | 850             | VO   | Yes             | Wi-Fi and BT                                           | NA                                          | NA                           |
|                                                                                                                                                    | 1900            |      |                 |                                                        |                                             | No                           |
|                                                                                                                                                    | GPRS/EDGE       | VD   | No              | Wi-Fi and BT                                           | Yes, Facetime                               | NA                           |
| W-CDMA (UMTS)                                                                                                                                      | 850             | VO   | No <sup>1</sup> | Wi-Fi and BT                                           | NA                                          | NA                           |
|                                                                                                                                                    | 1700            |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 1900            | VD   | No              | Wi-Fi and BT                                           | Yes, Facetime                               | NA                           |
| CDMA                                                                                                                                               | HSPA            |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 800             | VO   | Yes             | Wi-Fi and BT                                           | NA                                          | NA                           |
|                                                                                                                                                    | 1700            |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 1900            | VD   | No              | Wi-Fi and BT                                           | Yes, Facetime                               | NA                           |
|                                                                                                                                                    | EVDO            |      |                 |                                                        |                                             |                              |
| LTE - FDD                                                                                                                                          | 700             | VD   | No <sup>1</sup> | Wi-Fi and BT                                           | Yes, Facetime                               | NA                           |
|                                                                                                                                                    | 850             |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 1700            |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 1900            |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 2300            |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 2600            |      |                 |                                                        |                                             |                              |
| LTE - TDD                                                                                                                                          | 2500            | VD   | Yes             | Wi-Fi and BT                                           | Yes, Facetime                               | NA                           |
| Wi-Fi                                                                                                                                              | 2450            | VD   | Yes             | WWAN and BT                                            | Yes, Facetime                               | NA                           |
|                                                                                                                                                    | 5200 (U-NII-1)  |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 5300 (U-NII-2A) |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 5500 (U-NII-2C) |      |                 |                                                        |                                             |                              |
|                                                                                                                                                    | 5800 (U-NII-3)  |      |                 |                                                        |                                             |                              |
| BT                                                                                                                                                 | 2450            | DT   | No              | WWAN and Wi-Fi                                         | NA                                          | NA                           |
| Type<br>VO: legacy Cellular Voice Service<br>DT: Digital Transport only (no voice)<br>VD: IP Voice Service over Digital Transport<br>BT: Bluetooth |                 |      |                 | Note:<br>1. Evaluated for MIF and low power exemption. |                                             |                              |

## 9. Modulation Interference Factor (MIF)

The HAC Standard ANSI C63.19 defines a new scaling using the Modulation Interference Factor (MIF) which replaces the need for the Articulation Weighting Factor (AWF) during the evaluation and is applicable to any modulation scheme.

The Modulation Interference factor (MIF, in dB) is added to the measured average E-field (in dBV/m) and converts it to the RF Audio Interference level (in dBV/m). This level considers the audible amplitude modulation components in the RF E-field. CW fields without amplitude modulation are assumed to not interfere with the hearing aid electronics. Modulations without time slots and low fluctuations at low frequencies have low MIF values, TDMA modulations with narrow transmission and repetition rates of few 100 Hz have high MIF values and give similar classifications as ANSI C63.19.

### Definitions

E-field probes have a bandwidth <10 kHz and can therefore not evaluate the RF envelope in the full audio band. DASY52 is therefore using the "indirect" measurement method according to ANSI C63.19 which is the primary method. These near field probes read the averaged E-field measurement. Especially for the new high peak-to-average (PAR) signal types, the probes shall be linearized by probe modulation response (PMR) calibration in order to not overestimate the field reading.

The evaluation method or the MIF is defined in ANSI C63.19 section D.7. An RMS demodulated RF signal is fed to a spectral filter (similar to an A weighting filter) and forwarded to a temporal filter acting as a quasi-peak detector. The averaged output of these filtering is called to a 1 kHz 80% AM signal as reference. MIF measurement requires additional instrumentation and is not well suited for evaluation by the end user with reasonable uncertainty. It may alternatively be determined through analysis and simulation, because it is constraint and characteristic for a communication signal. DASY52 uses well defined signals for PMR calibration. The MIF of these signals has been determined by simulation and is automatically applied.

MIF values were not tested by a probe or as specified in the standards but are based on analysis provided by SPEAG for all the air interfaces (GSM, WCDMA, CDMA, LTE). The data included in this report are for the worst case operating modes. The UIDs used are listed below:

| UID       | Communication System Name                                 | MIF (dB) |
|-----------|-----------------------------------------------------------|----------|
| 10021-DAC | GSM-FDD (TDMA, GMSK)                                      | 3.63     |
| 10011-CAB | UMTS-FDD (WCDMA)                                          | -27.23   |
| 10295-AAB | CDMA2000 (1xRTT, RC1, SO3, 1/8 <sup>th</sup> Rate 25 fr.) | 3.26     |
| 10170-CAD | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, 16QAM)                    | -9.76    |
| 10182-CAD | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, 16QAM)                    | -9.76    |
| 10176-CAE | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 16QAM)                    | -9.76    |
| 10173-CAD | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16QAM)                    | -1.44    |
| 10061-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps)                 | -2.02    |
| 10077-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 54 Mbps)            | 0.12     |
| 10069-CAC | IEEE 802.11a/n WiFi 5 GHz (OFDM, 54 Mbps)                 | -3.15    |

A PMR calibrated probe is linearized for the selected waveform over the full dynamic range within the uncertainty specified in its calibration certificate. E-field probes have a bandwidth <10 kHz and can therefore not evaluate the RF envelope in the full audio band. DASY52 is therefore using the "indirect" measurement method according to ANSI C63.19 which is the primary method. These near field probes read the averaged E-field measurement. Especially for the new high peak-to-average (PAR) signal types, the probes shall be linearized by PMR calibration in order to not overestimate the field reading.

The MIF measurement uncertainty is estimated as follows, for modulation frequencies from slotted waveforms with fundamental frequency and at least 2 harmonics within 10 kHz:

- 0.2 dB for MIF -7 to +5 dB,
- 0.5 dB for MIF -13 to +11 dB
- 1 dB for MIF > -20 dB

## 10. HAC RF Emissions Test Procedure

The following are step-by-step test procedures.

- a) Confirm proper operation of the field probe, probe measurement system and other instrumentation and the positioning system.
- b) Position the WD in its intended test position.
- c) Set the WD to transmit a fixed and repeatable combination of signal power and modulation characteristic that is representative of the worst case (highest interference potential) encountered in normal use. Transiently occurring start-up, changeover, or termination conditions, or other operations likely to occur less than 1% of the time during normal operation, may be excluded from consideration.
- d) The center sub-grid shall be centered on the T-Coil mode perpendicular measurement point or the acoustic output, as appropriate. Locate the field probe at the initial test position in the 50 mm by 50 mm grid, which is contained in the measurement plane, refer to illustrated in Figure 1. If the field alignment method is used, align the probe for maximum field reception.
- e) Record the reading at the output of the measurement system
- f) Scan the entire 50 mm by 50 mm region in equally spaced increments and record the reading at each measurement point. The distance between measurement points shall be sufficient to assure the identification of the maximum reading.
- g) Identify the five contiguous sub-grids around the center sub-grid whose maximum reading is the lowest of all available choices. This eliminates the three sub-grids with the maximum readings. Thus, the six areas to be used to determine the WD's highest emissions are identified.
- h) Identify the maximum reading within the non-excluded sub-grids identified in step g).
- i) Convert the highest field reading within identified in step h) to RF audio interference level, in V/m, by taking the square root of the reading and then dividing it by the measurement system transfer function, established in 5.5.1.1 Convert this result to dB(V/m) by taking the base-10 logarithm and multiplying by 20.

### Indirect measurement method

Replacing step i), the RF audio interference level in dB (V/m) is obtained by adding the MIF (in dB) to the maximum steady-state rms field-strength reading, in dB (V/m), from step h). Use this result to determine the category rating

- j) Compare this RF audio interference level with the categories in Clause 8 (ANSI C63.19) and record the resulting WD category rating
- k) For the T-Coil mode M-rating assessment, determine whether the chosen perpendicular measurement point is contained in an included sub-grid of the first scan. If so, then a second scan is not necessary. The first scan and resultant category rating may be used for the T-Coil mode M rating.

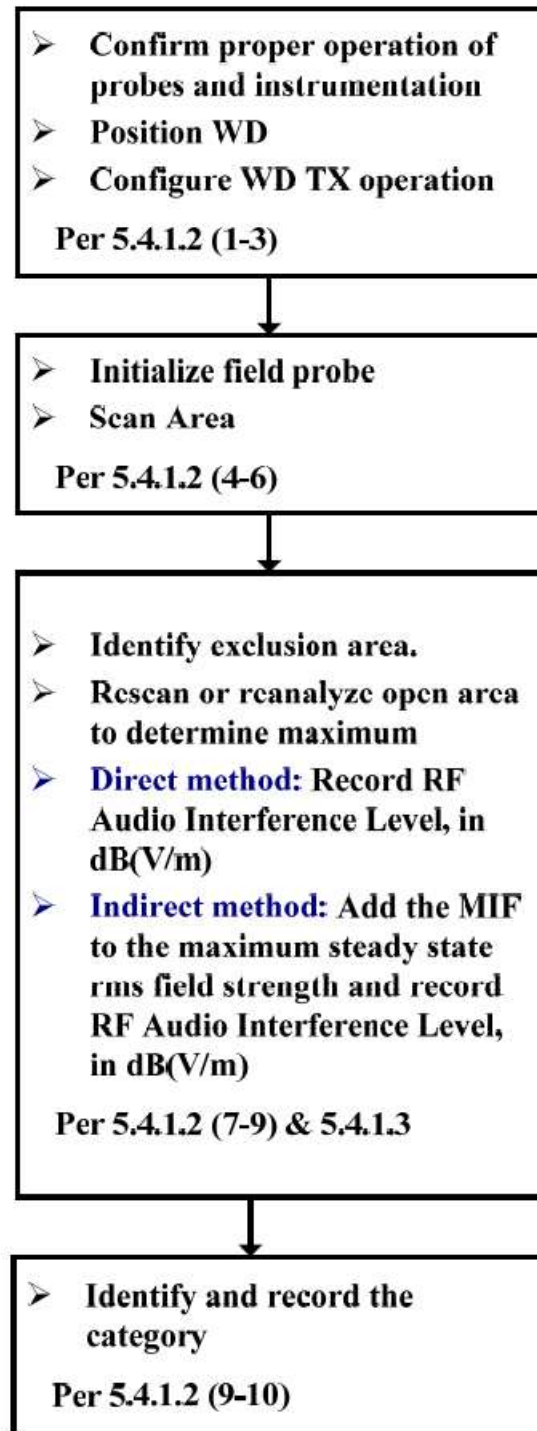
Otherwise, repeat step a) through step i), with the grid shifted so that it is centered on the perpendicular measurement point. Record the WD category rating.



Figure 1 - WD reference and plane for RF emission measurements



## Test flowchart Per ANSI-63.19-2011



## 11. RF Emissions Measurement Criteria

WD RF audio interference level categories in logarithmic units

| Emission Categories | E-field emissions |                   |
|---------------------|-------------------|-------------------|
|                     | < 960 MHz         | > 960 MHz         |
| Category M1         | 50 to 55 dB (V/m) | 40 to 45 dB (V/m) |
| Category M2         | 45 to 50 dB (V/m) | 35 to 40 dB (V/m) |
| Category M3         | 40 to 45 dB (V/m) | 30 to 35 dB (V/m) |
| Category M4         | <40 dB (V/m)      | <30 dB (V/m)      |

## 12. HAC (RF Emissions) Test Results

MIF values were not tested by a probe or as specified in the standards but are based on analysis provided by SPEAG for the following User Identifiers and air interfaces.

The data included in this report are for the worst case operating modes. Refer to Appendix D and G for the MIF values that represent the worst case operation modes.

Refer to Section 7 Evaluation for Low-power Exemption. RF Emission testing for this device is required only for GSM, CDMA voice modes, LTE-TDD, Wi-Fi and Bluetooth. All other applicable air-interfaces are exempt from testing in accordance with C63.19 Clause 4.4 and are rated M4.

### 12.1. ANT1

| Air-Interface          | Ch. No.    | Freq. (MHz) | Results*<br>(dB V/m) | Results<br>plus 0.2dB uncertainty<br>(dB V/m) | Margin<br>(dB) | M-Rating  | Plots<br>Page # |
|------------------------|------------|-------------|----------------------|-----------------------------------------------|----------------|-----------|-----------------|
| GSM850                 | 128        | 824.4       | 35.07                | 35.27                                         | 4.73           | M4        | 1               |
|                        | 190        | 836.6       | 35.21                | 35.41                                         | 4.59           | M4        | 2               |
|                        | 251        | 848.6       | 35.22                | 35.42                                         | 4.58           | M4        | 3               |
| GSM1900                | 512        | 1850.2      | 32.89                | 33.09                                         | 1.91           | M3        | 4               |
|                        | <b>661</b> | <b>1880</b> | <b>32.91</b>         | <b>33.11</b>                                  | <b>1.89</b>    | <b>M3</b> | <b>5</b>        |
|                        | 810        | 1909.8      | 32.76                | 32.96                                         | 2.04           | M3        | 6               |
| CDMA2000<br>BC0        | 1013       | 824.7       | 26.09                | 26.29                                         | 13.71          | M4        | 7               |
|                        | 384        | 836.6       | 26.10                | 26.30                                         | 13.70          | M4        | 8               |
|                        | 777        | 848.31      | 25.99                | 26.19                                         | 13.81          | M4        | 9               |
| CDMA2000<br>BC1        | 25         | 1851.25     | 26.24                | 26.44                                         | 3.56           | M4        | 10              |
|                        | 600        | 1880        | 26.90                | 27.10                                         | 2.90           | M4        | 11              |
|                        | 1175       | 1908.75     | 26.76                | 26.96                                         | 3.04           | M4        | 12              |
| CDMA2000<br>BC10       | 450        | 817.3       | 29.05                | 29.25                                         | 10.75          | M4        | 13              |
|                        | 560        | 820         | 29.91                | 30.11                                         | 9.89           | M4        | 14              |
|                        | 670        | 822.75      | 29.32                | 29.52                                         | 10.48          | M4        | 15              |
| LTE-TDD<br>Band 41 PC3 | 39750      | 2506        | 22.83                | 23.03                                         | 6.97           | M4        | 16              |
|                        | 40185      | 2549.5      | 22.28                | 22.48                                         | 7.52           | M4        | 17              |
|                        | 40620      | 2593        | 21.78                | 21.98                                         | 8.02           | M4        | 18              |
|                        | 41055      | 2636.5      | 21.23                | 21.43                                         | 8.57           | M4        | 19              |
|                        | 41490      | 2680        | 19.77                | 19.97                                         | 10.03          | M4        | 20              |
| LTE-TDD<br>Band 41 PC2 | 39750      | 2506.00     | 23.39                | 23.59                                         | 6.41           | M4        | 77              |
|                        | 40185      | 2549.50     | 23.01                | 23.21                                         | 6.79           | M4        | 78              |
|                        | 40620      | 2593.00     | 22.46                | 22.66                                         | 7.34           | M4        | 79              |
|                        | 41055      | 2636.50     | 21.93                | 22.13                                         | 7.87           | M4        | 80              |
|                        | 41490      | 2680.00     | 20.71                | 20.91                                         | 9.09           | M4        | 81              |

#### Note(s):

\*: Measured Audio Interference level in dB (V/m): indirect method (max rms field strength Plus MIF)

**12.2. ANT2**

| Air-Interface          | Ch. No. | Freq. (MHz) | Results*<br>(dB V/m) | Results<br>plus 0.2dB uncertainty<br>(dB V/m) | Margin<br>(dB) | M-Rating | Plots<br>Page # |
|------------------------|---------|-------------|----------------------|-----------------------------------------------|----------------|----------|-----------------|
| GSM850                 | 128     | 824.4       | 35.99                | 36.19                                         | 3.81           | M4       | 21              |
|                        | 190     | 836.6       | 35.72                | 35.92                                         | 4.08           | M4       | 22              |
|                        | 251     | 848.6       | 35.35                | 35.55                                         | 4.45           | M4       | 23              |
| GSM1900                | 512     | 1850.2      | 29.00                | 29.20                                         | 0.80           | M4       | 24              |
|                        | 661     | 1880        | 28.78                | 28.98                                         | 1.02           | M4       | 25              |
|                        | 810     | 1909.8      | 28.99                | 29.19                                         | 0.81           | M4       | 26              |
| CDMA2000<br>BC0        | 1013    | 824.7       | 33.90                | 34.10                                         | 5.90           | M4       | 27              |
|                        | 384     | 836.6       | 33.47                | 33.67                                         | 6.33           | M4       | 28              |
|                        | 777     | 848.31      | 32.88                | 33.08                                         | 6.92           | M4       | 29              |
| CDMA2000<br>BC1        | 25      | 1851.25     | 28.07                | 28.27                                         | 1.73           | M4       | 30              |
|                        | 600     | 1880        | 27.40                | 27.60                                         | 2.40           | M4       | 31              |
|                        | 1175    | 1908.75     | 27.54                | 27.74                                         | 2.26           | M4       | 32              |
| CDMA2000<br>BC10       | 450     | 817.3       | 33.81                | 34.01                                         | 5.99           | M4       | 33              |
|                        | 560     | 820         | 33.89                | 34.09                                         | 5.91           | M4       | 34              |
|                        | 670     | 822.75      | 33.94                | 34.14                                         | 5.86           | M4       | 35              |
| LTE-TDD<br>Band 41 PC3 | 39750   | 2506        | 31.89                | 32.09                                         | 2.91           | M3       | 36              |
|                        | 40185   | 2549.5      | 31.15                | 31.35                                         | 3.65           | M3       | 37              |
|                        | 40620   | 2593        | 29.83                | 30.03                                         | 4.97           | M3       | 38              |
|                        | 41055   | 2636.5      | 28.87                | 29.07                                         | 0.93           | M4       | 39              |
|                        | 41490   | 2680        | 28.36                | 28.56                                         | 1.44           | M4       | 40              |
| 802.11b                | 2       | 2417        | 30.59                | 30.79                                         | 4.21           | M3       | 41              |
|                        | 6       | 2437        | 29.75                | 29.95                                         | 0.05           | M4       | 42              |
|                        | 11      | 2462        | 29.37                | 29.57                                         | 0.43           | M4       | 43              |
| 802.11g                | 3       | 2422        | 31.36                | 31.56                                         | 3.44           | M3       | 44              |
|                        | 6       | 2437        | 31.42                | 31.62                                         | 3.38           | M3       | 45              |
|                        | 9       | 2452        | 31.50                | 31.70                                         | 3.30           | M3       | 46              |

**Note(s):**

\*: Measured Audio Interference level in dB (V/m): indirect method (max rms field strength Plus MIF)

**12.3. ANT4**

| Air-Interface      | Ch. No. | Freq. (MHz) | Results*<br>(dB V/m) | Results<br>plus 0.2dB uncertainty<br>(dB V/m) | Margin<br>(dB) | M-Rating | Plots<br>Page # |
|--------------------|---------|-------------|----------------------|-----------------------------------------------|----------------|----------|-----------------|
| 802.11 a (5.2 GHz) | 40      | 5200        | 22.75                | 22.95                                         | 7.05           | M4       | 47              |
|                    | 44      | 5220        | 22.35                | 22.55                                         | 7.45           | M4       | 48              |
|                    | 48      | 5240        | 23.16                | 23.36                                         | 6.64           | M4       | 49              |
| 802.11 a (5.3 GHz) | 52      | 5260        | 23.29                | 23.49                                         | 6.51           | M4       | 50              |
|                    | 56      | 5280        | 23.64                | 23.84                                         | 6.16           | M4       | 51              |
|                    | 60      | 5300        | 24.07                | 24.27                                         | 5.73           | M4       | 52              |
| 802.11 a (5.5 GHz) | 104     | 5520        | 23.98                | 24.18                                         | 5.82           | M4       | 53              |
|                    | 124     | 5620        | 25.16                | 25.36                                         | 4.64           | M4       | 54              |
|                    | 144     | 5720        | 26.67                | 26.87                                         | 3.13           | M4       | 55              |
| 802.11 a (5.8 GHz) | 149     | 5745        | 26.67                | 26.87                                         | 3.13           | M4       | 56              |
|                    | 157     | 5785        | 26.99                | 27.19                                         | 2.81           | M4       | 57              |
|                    | 165     | 5825        | 27.63                | 27.83                                         | 2.17           | M4       | 58              |

**Note(s):**

\*: Measured Audio Interference level in dB (V/m): indirect method (max rms field strength Plus MIF)

**12.4. ANT5**

| Air-Interface     | Ch. No. | Freq. (MHz) | Results*<br>(dB V/m) | Results<br>plus 0.2dB uncertainty<br>(dB V/m) | Margin<br>(dB) | M-Rating | Plots<br>Page # |
|-------------------|---------|-------------|----------------------|-----------------------------------------------|----------------|----------|-----------------|
| 802.11b           | 2       | 2417        | 29.64                | 29.84                                         | 0.16           | M4       | 59              |
|                   | 6       | 2437        | 29.40                | 29.60                                         | 0.40           | M4       | 60              |
|                   | 11      | 2462        | 29.52                | 29.72                                         | 0.28           | M4       | 61              |
| 802.11g           | 3       | 2422        | 26.80                | 27.00                                         | 3.00           | M4       | 62              |
|                   | 6       | 2437        | 26.85                | 27.05                                         | 2.95           | M4       | 63              |
|                   | 9       | 2452        | 26.95                | 27.15                                         | 2.85           | M4       | 64              |
| 802.11a (5.2 GHz) | 40      | 5200        | 18.26                | 18.46                                         | 11.54          | M4       | 65              |
|                   | 44      | 5220        | 18.01                | 18.21                                         | 11.79          | M4       | 66              |
|                   | 48      | 5240        | 17.50                | 17.70                                         | 12.30          | M4       | 67              |
| 802.11a (5.3 GHz) | 52      | 5260        | 17.65                | 17.85                                         | 12.15          | M4       | 68              |
|                   | 56      | 5280        | 16.84                | 17.04                                         | 12.96          | M4       | 69              |
|                   | 60      | 5300        | 17.68                | 17.88                                         | 12.12          | M4       | 70              |
| 802.11a (5.5 GHz) | 104     | 5520        | 15.61                | 15.81                                         | 14.19          | M4       | 71              |
|                   | 124     | 5620        | 16.12                | 16.32                                         | 13.68          | M4       | 72              |
|                   | 144     | 5720        | 15.71                | 15.91                                         | 14.09          | M4       | 73              |
| 802.11a (5.8 GHz) | 149     | 5745        | 16.42                | 16.62                                         | 13.38          | M4       | 74              |
|                   | 157     | 5785        | 16.20                | 16.40                                         | 13.60          | M4       | 75              |
|                   | 165     | 5825        | 16.00                | 16.20                                         | 13.80          | M4       | 76              |

**Note(s):**

\*: Measured Audio Interference level in dB (V/m): indirect method (max rms field strength Plus MIF)

## 12.5. Worst Case RF Emission Test Plot

Test Laboratory: UL Verification Services Inc. SAR Lab C

Date: 7/19/2018

### HAC-RF Emission ANT 1

Communication System: UID 10021 - DAC, GSM-FDD (TDMA, GMSK); Frequency: 1880 MHz; Duty Cycle: 1:8.6896

Phantom section: RF Section

DASY5 Configuration:

- Probe: EF3DV3 - SN4041; ConvF(1, 1, 1); Calibrated: 3/16/2018;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1472; Calibrated: 3/8/2018
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BB
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

### GSM1900 E-Field measurement/Voice\_ch 661/Hearing Aid Compatibility Test

(101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 32.64 V/m; Power Drift = -0.06 dB

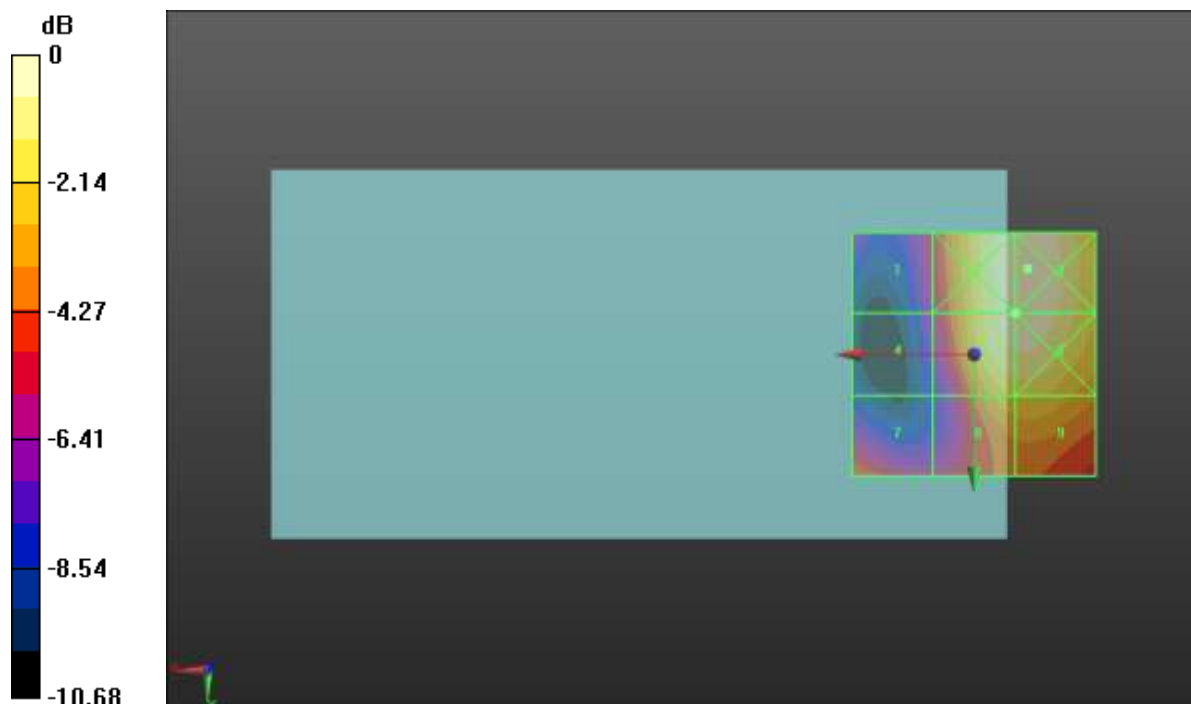
Applied MIF = 3.63 dB

RF audio interference level = 32.91 dBV/m

Emission category: **M3**

MIF scaled E-field

|                                 |                                 |                                 |
|---------------------------------|---------------------------------|---------------------------------|
| Grid 1 <b>M4</b><br>27.87 dBV/m | Grid 2 <b>M3</b><br>33.13 dBV/m | Grid 3 <b>M3</b><br>33.21 dBV/m |
| Grid 4 <b>M4</b><br>27.02 dBV/m | Grid 5 <b>M3</b><br>32.91 dBV/m | Grid 6 <b>M3</b><br>32.98 dBV/m |
| Grid 7 <b>M4</b><br>29.22 dBV/m | Grid 8 <b>M3</b><br>31.1 dBV/m  | Grid 9 <b>M3</b><br>31.19 dBV/m |



0 dB = 45.78 V/m = 33.21 dBV/m

## **Appendixes**

**Refer to separated files for the following appendixes**

**12258201-S4V1 Appendix A: HAC RF Emission Setup Photo**

**12258201-S4V1 Appendix B: System Validation Plots**

**12258201-S4V1 Appendix C: HAC RF Emission Test Plots**

**12258201-S4V1 Appendix D: MIF Attestation Letter**

**12258201-S4V1 Appendix E: Probe Calibration Certificates**

**12258201-S4V1 Appendix F: Dipole Calibration Certificates**

**12258201-S4V1 Appendix G: UID Specifications**

**END OF REPORT**